Q1.

1 (a) scalar: magnitude only  B1
    vector: magnitude and direction (allow scalar with direction)  B1  [2]

   (allow 1 mark for scalar has no direction, vector has direction)
(b) diagram has correct shape  M1
   with arrows in correct directions  A1
   resultant = 13.2 ± 0.2 N  (allow 2 sig. fig)  A2  [4]
   (for 12.8 → 13.0 and 13.4 → 13.6, allow 1 mark)
   (calculated answer with a correct sketch, allow max 4 marks)
   (calculated answer with no sketch – no marks)
   Total  [6]

Q2.

4 (a) (i) \( p = \frac{1}{2} mv \)  B1
   (ii) \( E_k = \frac{1}{2} mv^2 \)  B1
   algebra leading to
   \( E_k = p^2/2m \)  A0  [3]

   (b) (i) \( \Delta p = 0.035 \times (4.5 + 3.5) \) OR \( a = (4.5 + 3.5)/0.14 \)
   \( = 0.28 \text{ N s} \)  C1
   \( \text{force} = \frac{\Delta p}{\Delta t} (= 0.28/0.14) \) OR \( F = ma (= 0.035 \times 57.1) \) (allow e.c.f.)  C1
   \( = 2.0 \text{ N} \)  A1
   Note: candidate may add \( m g = 0.34 \text{ N} \) to this answer, deduct 1 mark upwards  B1  [4]
   (ii) \( \text{loss} = \frac{1}{2} \times 0.035 \times (4.5^2 - 3.5^2) \)
   \( = 0.14 \text{ J} \)  C1
   \( \text{A1} \)  [2]
   (No credit for \( 0.28^2/(2 \times 0.035) = 1.12 \text{ J} \))

   (c) e.q. plate (and Earth) gain momentum
   \( i.e. \text{discusses a system} \)  B1
   \( \text{equal and opposite to the change for the ball} \)  B1
   \( i.e. \text{discusses force/momentum} \)  M1
   \( \text{so momentum is conserved} \)  A1  [3]

   Total  [12]

Q3.

5 (a) (i) distance = 2\( \pi \)r  B1
   (ii) work done = \( F \times 2 \pi \)r  A0  [2]

   (b) total work done = \( 2 \times F \times 2 \pi \)r
   but torque \( T = 2Fr \)
   hence work done = \( T \times 2\pi \)r  B1

   (c) power = work done/time (= 470 \( \times 2 \pi \times 2400 \))/80
   \( = 1.2 \times 10^6 \text{ W} \)  A1  [2]

   Total  [6]

Q4.
3. (a) (i) \( \Delta E_p = mg \Delta h \)
   \[ = 0.602 \times 9.8 \times 0.086 \]
   \[ = 0.51 \text{ J} \]  
   (do not allow \( q = 10, m = 0.600 \) or answer \( 0.50 \text{ J} \))  
   \( C1 \)  
   \( A1 \)  
   \( [2] \)  

   (ii) \( v^2 = (2gh) = 2 \times 9.8 \times 0.086 \) or \( (2 \times 0.51)/0.602 \)  
   \[ v = 1.3 \text{ (m s}^{-1} ) \]  
   \( M1 \)  
   \( A0 \)  
   \( [1] \)  

   (b) \[ 2 \times V = 602 \times 1.3 \] (allow 600)  
   \[ V = 390 \text{ m s}^{-1} \]  
   \( C1 \)  
   \( A1 \)  
   \( [2] \)  

   (c) (i) \( E_k = \frac{1}{2}mv^2 \)
   \[ = \frac{1}{2} \times 0.002 \times 390^2 \]
   \[ = 152 \text{ J or } 153 \text{ J or } 150 \text{ J} \]  
   \( C1 \)  
   \( A1 \)  
   \( [2] \)  

   (ii) \( E_k \) not the same/changes  
   or \( E_k \) before impact > \( E_k \) after/\( E_k \) after  
   so must be inelastic collision  
   (allow 1 mark for ‘bullet embeds itself in block’ etc.)  
   \( M1 \)  
   \( A1 \)  
   \( [2] \)  

Q5.  

2. (a) (i) point at which whole weight of body  
   may be considered to act  
   \( M1 \)  
   \( A1 \)  
   \( [2] \)  

   (ii) sum of forces in any direction is zero  
   sum of moments about any point is zero  
   \( B1 \)  
   \( B1 \)  
   \( [2] \)  

   (b) either:  
   \( T \) and \( W \) have zero moment about \( P \)  
   so \( F \) must have zero moment, i.e. pass through \( P \)  
   \( M1 \)  
   \( A1 \)  
   \( [2] \)  

   or:  
   if all pass through \( P \), distance from \( P \) is zero for all forces  
   so sum of moments about \( P \) is zero  
   \( (M1) \)  
   \( (A1) \)  

   (c) (i) \( F \cos \alpha = T \cos \beta \)  
   \( B1 \)  
   \( [1] \)  

   (ii) \( W = F \sin \alpha + T \sin \beta \)  
   \( B1 \)  
   \( [1] \)  

   (iii) \( 2W = 3T \sin \beta \)  
   \( B1 \)  
   \( [1] \)  

Q6.  

www.youtube.com/megalecture
3 (a) (i) \( v^2 = 2as \)
\[ 1.2^2 = 2 \times a \times 1.9 \]
\[ a = 0.38 \text{ m s}^{-2} \]
M1
A1 [2]

(ii) \( F = ma \)
\[ = 42 \times 0.38 \]
\[ = 16 \text{ N} \]
M1
A0 [1]

(b) power \( = Fv \)
\[ = 16 \times 1.2 \]
\[ = 19 \text{ W} \]
C1
A1 [2]

(c) (i) component \[ = 42 \times 9.8 \times \sin2.8 \]
\[ = 20.1 \text{ N} \]
C1
A1 [2]

(ii) accelerating force \[ = 20.1 - 16 = 4.1 \text{ N} \]
acceleration of trolley \[ = 4.1 / 42 = 0.098 \text{ m s}^{-2} \]
\( s = \frac{1}{2}at^2 \)
\[ 3.5 = \frac{1}{2} \times 0.098 \times t^2 \]
\[ t = 8.5 \text{ s} \]
C1
C1

(d) either allows plenty of time to stop runaway trolley
or speed of trolley increases gradually
or trolley will travel faster
(answer must be unambiguous when read in conjunction with question)
B1 [1]

Q7.

2 (a) (i) \( k \) is the reciprocal of the gradient of the graph
\[ k = \frac{32 / (4 \times 10^{-2})}{= 1800 \text{ N m}^{-1}} \]
C1
A1 [2]

(ii) either energy \( = \) average force \( \times \) extension or \( \frac{1}{2}kx^2 \)
or area under graph line
energy \[ = \frac{1}{2} \times 800 \times (3.5 \times 10^{-2})^2 \] or \[ \frac{1}{2} \times 28 \times 3.5 \times 10^{-2} \]
energy \[ = 0.49 \text{ J} \]
C1
M1
A0 [2]

(b) (i) momentum before cutting thread \( = \) momentum after
\[ 0 = 2400 \times v - 800 \times (v / \sqrt{v}) \]
\[ v / \sqrt{v} = 3 \]
C1
M1
A0 [2]

(iii) energy stored in spring \( = \) kinetic energy of trolleys
\[ 0.49 = \frac{1}{2} \times 2.4 \times (\frac{1}{3}v)^2 + \frac{1}{2} \times 0.8 \times v^2 \]
\[ v = 0.96 \text{ m s}^{-1} \]
(Cif only one trolley considered, or masses combined, allow max 1 mark)
C1
C1
A1 [3]

Q8.
2  (a) ball moving in opposite direction (after collision) ........................................... B1      [1]

(b)  (i) change in momentum = 1.2 (4.0 + 0.8) ......................................................... C2
     (correct values, 1 mark; correct sign {values added}, 1 mark)
     = 5.76 Ns ...(allow 5.8) .................................. A1      [3]

     (ii) force = Δp / Δt or mΔv / Δt ............................................................ C1
          = 5.76 / 0.08 or 1.2 × 4.8 / 0.08 ........................................... C1
          = 72 N ...................................................... A1      [3]

(c)  5.76 = 3.6 × V .......................................................... C1
     V = 1.6 m s\(^{-1}\) ..................................................... A1      [2]

(d) either speed of approach = 4.0 m s\(^{-1}\) and
    speed of separation = 2.4 m s\(^{-1}\) ................................. M1
    not equal and so inelastic ........................................ A1

    or kinetic energy before = 9.6 J and
    kinetic energy after collision = 4.99 J ............................. M1
    kinetic energy after is less / not conserved so inelastic ....... A1      [2]

Q9.

3  (a) product of (magnitude of one) force and distance between forces ..... M1
    reference to either perpendicular distance between forces
    or line of action of forces and perpendicular distance .... A1      [2]

(b)  (i) 90° ................................................................. B1      [1]

     (ii) 130 = F × 0.45  (allow e.c.f. for angle in (i)) .................. C1
          (allow 1 mark only if angle stated in (i) is not used in (ii))

Q10.
Q11.

2  (a) 2.4 s .......................................................... A1 [1]

(b) in (b) and (c), allow answers as (+) or (−)
    recognises distance travelled as area under graph line ........................................... C1
    height = \( \frac{1}{2} \times 2.4 \times 9.0 \) − \( \frac{1}{2} \times 1.6 \times 6.0 \) ........................................ C1
    = 6.0 m (allow 6 m) .................................................................................................. A1 [3]
    (answer 15.6 scores 2 marks
    answer 10.8 or 4.8 scores 1 mark)

    alternative solution: \( s = ut - \frac{1}{2}at^2 \)
    = \( (9 \times 4) - \frac{1}{2} \times (9 / 2.4) \times 4^2 \)
    = 6.0 m
    (answer 66 scores 2 marks
    answer 36 or 30 scores 1 mark)

(c)  (ii) change in momentum = 0.78 (9.0 + 4.2) (allow 4.2 ± 0.2) ......................... C1
    = 10.3 N s (allow 10 N s) ......................................................................................... A1 [2]

    (ii) force = \( \Delta p / \Delta t \) or \( m\Delta v / \Delta t \) ................................................................. C1
    = 10.3 / 3.5 / 0.08
    = 2.9 N ...................................................................................................................... A1 [2]

(d)  (i) 2.9 N ..................................................................................................................... A1 [1]

    (ii) \( g = \text{weight} / \text{mass} \) ......................................................................................... C1
    = 2.9 / 0.78
    = 3.7 m s\(^{-2}\) .......................................................................................................... A1 [2]

Q11.

3  (a) either energy (stored)/work done represented by area under graph
    or energy = average force × extension ......................................................................... B1
    energy = \( \frac{1}{2} \times 180 \times 4.0 \times 10^{-2} \)
    = 3.6 J .......................................................................................................................... A1 [3]

(b)  (i) either momentum before release is zero .............................................................. M1
    so sum of momenta (of trolleys) after release is zero ................................................ A1
    or force = rate of change of momentum (M1)
    force on trolleys equal and opposite (A1)
    or impulse = change in momentum (M1)
    impulse on each equal and opposite (A1)

    (ii) 1 \( M_1 V_1 = M_2 V_2 \) ........................................................................................ B1 [1]

    2 \( E = \frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 V_2^2 \) ........................................................................ B1 [1]

    (iii) 1 \( E_K = \frac{1}{2} m v^2 \) and \( p = m v \) combined to give .......................................... M1
    \( E_K = \frac{p^2}{2m} \) ........................................................................................................ A0 [1]

    2 \( m \text{ smaller, } E_K \text{ is larger because } p \text{ is the same/constant} \) ....................... M1
    so trolley B ..................................................................................................................... A0 [1]
Q12.

3 (a) (i) force is rate of change of momentum ...................................................... B1 [1]

(ii) force on body A is equal in magnitude to force on body B (from A) .......... M1 forces are in opposite directions .......................................................... A1 forces are of the same kind ............................................A1 [3]

(b) (i) \[ F_A = -F_B \] ................................................................. B1 [1]

\[ t_A = t_B \] ................................................................. B1 [1]

(ii) \[ \Delta p = F_A t_A = -F_B t_B \] ................................................................. B1 [1]

(c) graph: momentum change occurs at same times for both spheres ........... B1 final momentum of sphere B is to the right ............................................ M1 and of magnitude 5 N s .............................................. A1 [3]

Q13.

2 (a) no resultant force/sum of forces zero ...................................................... B1

no resultant moment/torque/sum of moments/torques zero ................. B1 [2]

(b) (i) each force is represented by the side of a triangle/by an arrow in magnitude and direction arrows joined, head to tail (could be shown on a sketch diagram) M1 A1 B1 [3]

(ii) if the triangle is ‘closed’ (then the forces are in equilibrium) ................. B1 [1]

(c) triangle drawn with correct shape (incorrect arrows loses this mark) B1

\[ T_1 = 5.4 \pm 0.2N \] ...................................................... B1

\[ T_2 = 4.0 \pm 0.2N \] ...................................................... B1 [3]

(d) forces in strings would be horizontal (so) no vertical force to support the weight B1 [2]

Q14.
Q15.

2 (a) resultant moment = zero / sum of clockwise moments = sum of anticlockwise moments
resultant force = 0

(b) shape and orientation correct and forces labelled and arrows correct
angles correct / labelled

(c) (i) \[ T \cos 18^\circ = W \]
\[ T = \frac{W}{\cos 18^\circ} = 547 \text{ N} \pm 20 \text{ N} \]

(ii) \[ R = T \sin 18^\circ = 169 \text{ N} \pm 20 \text{ N} \]

(d) \( \theta \) is larger, hence \( \cos \theta \) is smaller, \( T = \frac{W}{\cos \theta} \)

Q16.
Q17.

2 (a) (i) \(v = u + at\)

\[= 4.23 + 9.81 \times 1.51\]

\[= 19.0(4) \text{ m s}^{-1}\] (Allow 2 s.f.)

(Use of \(-g\) max 1/2. Use of \(g = 10\) max 1/2. Allow use of 9.8. Allow 19 m s\(^{-1}\))

(ii) either \(s = ut + \frac{1}{2} at^2\) (or \(v^2 = u^2 + 2as\) etc.)

\[= 4.23 \times 1.51 + 0.5 \times 9.81 \times (1.51)^2\]

\[= 17.6 \text{ m (or } 17.5\text{m)}\]

(Use of \(-g\) here wrong physics (0/2))

(b) (i) \(F = \frac{\Delta P}{\Delta t}\) need idea of change in momentum

\[= \frac{0.0465 \times (18.6 + 19)}{12.5 \times 10^{-3}}\]

\[= 140\text{N}\]

(Use of \(-g\) sign max 2/4. Ignore \(-ve\) sign in answer)

Direction: upwards

B1 [4]

(ii) \(h = \frac{1}{2} \times (18.6)^2 / 9.81\)

\[= 17.6 \text{ m (2 s.f. \(-1\))}\]

(Use of 19 m s\(^{-1}\). 0/2 wrong physics)

(c) either kinetic energy of the ball is not conserved on impact

or speed before impact is not equal to speed after hence inelastic

B1 [1]

Q18.
3 (a) A body continues at rest or constant velocity unless acted on by a resultant
(external) force

(b) (i) constant velocity/zero acceleration and therefore no resultant force
M1
no resultant force (and no resultant torque) hence in equilibrium
A1 [2]

(ii) component of weight = 450 \times 9.81 \times \sin 12^\circ (= 917.8) 
C1
tension = 650 + 450 \times \sin 12^\circ = (650 + 917.8) 
C1
= 1600 (1570)N
A1 [3]

(iii) work done against frictional force or friction between log and slope
M1
output power greater than the gain in PE / s 
A1 [2]

Q19.

1 (a) displacement is a vector, distance is a scalar
B1
displacement is straight line between two points / distance is sum of lengths
moved / example showing difference
B1 [2]
(either one of the definitions for the second mark)

(b) a body continues at rest or at constant velocity unless acted on by a resultant
(external) force
B1 [1]

(c) (i) sum of T_1 and T_2 equals frictional force
B1
these two forces are in opposite directions
B1 [2]
(allow for 1/2 for travelling in straight line hence no rotation / no resultant
torque)

(ii) 1. scale vector triangle with correct orientation / vector triangle with correct
orientation both with arrows
B1
scale given or mathematical analysis for tensions
B1 [2]

2. T_1 = 10.1 \times 10^3 (\pm 0.5 \times 10^3) N 
A1 
T_2 = 16.4 \times 10^3 (\pm 0.5 \times 10^3) N 
A1 [2]

Q20.
Q21.

2 (a) weight = \(452 \times 9.81\) 
component down the slope = \(452 \times 9.81 \times \sin 14^\circ\) 
= 1072.7 = 1070 N 

(b) (i) \(F = ma\) 
\[
T - (1070 + 525) = 452 \times 0.13
\]
\[
T = 1650 (1653.76) N \quad \text{any forces missing 1/3}
\]

(ii) 1. \(s = ut + \frac{1}{2}at^2\) hence \(10 = 0 + \frac{1}{2} \times 0.13t^2\) 
\[
t = [(2 \times 10) / 0.13]^{1/2} = 12.4 \text{ or } 12 \text{ s}
\]
2. \(v = (0 + 2 \times 0.13 \times 10)^{1/2} = 1.61 \text{ or } 1.6 \text{ ms}^{-1}\)

(c) straight line from the origin 
line down to zero velocity in short time compared to stage 1 
line less steep negative gradient 
final velocity larger than final velocity in the first part – at least 2x

Q22.

2 (a) mass is the property of a body resisting changes in motion / quantity of 
matter in a body / measure of inertia to changes in motion

weight is the force due to the gravitational field/force due to gravity 
or gravitational force

Allow 1/2 for ‘mass is scalar weight is vector’

(b) (i) arrow vertically down through O 
tension forces in correct direction on rope

(ii) 1. weight = \(mg = 4.9 \times 9.81 \approx 48.07\)
\[
69 \sin \theta = mg
\]
\[
\theta = 44.(1)^\circ \quad \text{scale drawing allow } \pm 2^\circ
\]

use of cos or tan 1/3 only

2. \(T = 69 \cos \theta\) 
\[
= 49.6 / 50N \quad \text{scale drawing } 50 \pm 2(2/2) \quad 50 \pm 4(1/2)
\]
correct answers obtained using scale diagram or triangle of forces will score 
full marks
\(cos \text{ in 1. then } sin \text{ in 2. } (2/2)\)
2 (a) force = rate of change of momentum

(b) (i) horizontal line on graph from \( t = 0 \) to \( t \) about 2.0 s ± ½ square, \( a > 0 \)  
horizontal line at 3.5 on graph from 0 to 2 s  
vertical line at \( t = 2.0 \) s to \( a = 0 \) or sharp step without a line  
horizontal line from \( t = 2 \) s to \( t = 4 \) s with \( a = 0 \)

(ii) straight line and positive gradient  
starting at (0,0)  
finishing at (2,16.8)  
horizontal line from 16.8  
from 2.0 to 4.0

Q23.

3 (a) the point where (all) the weight (of the body) is considered / seems to act

(b) (i) vertical component of \( T (= 30 \cos 40^\circ) = 23 \) N

(ii) the sum of the clockwise moments about a point equals the sum of the anticlockwise moments about the same point

(iii) (moments about \( A \)): \( 23 \times 1.2 (27.58) = 8.5 \times 0.60 + 1.2 \times W \)

working to show \( W = 19 \) or answer of 18.73 (N)

(iv) \( M = W / g = 18.73 / 9.81 = 1.909 \) kg

(c) (for equilibrium) resultant force (and moment) = 0
upward force does not equal downward force / horizontal component of \( T \) not balanced by forces shown

Q24.

3 (a) (i) the total momentum of a system (of interacting bodies) remains constant provided there are no resultant external forces / isolated system

(ii) elastic: total kinetic energy is conserved, inelastic: loss of kinetic energy [allow elastic: relative speed of approach equals relative speed of separation]
Q25.

2 (a) mass: measure of body's resistance/inertia to changes in velocity/motion ........................................ B1
weight: effect of gravitational field on mass or force of gravity ..... B1
any further comment e.g. mass constant, weight varies/ weight = mg/scalar and vector ........................................... B1 [3]

(b) e.g. where gravitational field strength changes (change) in fluid surrounding body .... 1 each, max 2 ................. B2 [2]

Q26.

3 (a) force x perpendicular distance .................................................. M1
(of the force) from the pivot .................................................. A1 [2]

(b) no resultant force (in any direction)............................................. B1
no resultant moment (about any point)................................. B1 [2]

(c) (i) correct direction in both .................................................. B1 [1]
(ii)1 moment = 150 x 0.3 = 45 N m (1 sig. fig. -1)......................... A1
(ii)2 torque = 45 N m i.e. same is (i) ............................................. A1
(ii)3 45 = 0.12 x T ................................................................. C1

Q27.

2 (a) point where whole weight of body (allow mass) may be considered to act (do not allow 'acts') M1
.................................................................................. A1 [2]

(b) when CG below pivot, weight acts through the pivot (so) weight has no turning effect about pivot B1
.................................................................................. B1 [2]

Q28.
3 (a) change in velocity/time (taken) B1 [1]
(b) velocity is a vector/velocity has magnitude & direction B1
direction changing so must be accelerating B1 [2]
(c) either \(6.1 \times \cos 35 = 4.99\) N or scale shown B1
so no resultant vertical force triangle of correct shape B1
\(6.1 \sin 35 = 3.5\) N resultant = \(3.5 \pm 0.2\) N B1
horizontally horizontal \(\pm 3^\circ\) B1 [4]

allow answer based on centripetal force:
resultant is centripetal force (which is horizontal) (B1)
resultant is horizontal component of tension (B1)
\(6.1 \sin 35 = 3.5\) N (B1)
horizontally (B1)

Q29.

4 (a) (i) use of tangent at time \(t = 0\) B1
acceleration = \(42 \pm 4\) cm \(s^{-2}\) A1 [2]
(ii) use of area of loop B1
distance = 0.031 \(\pm\) 0.001 m B2 [3]
allow 1 mark if 0.031 \(\pm\) 0.002 m

(b) (i) \(F = ma\) C1
\[= 0.93 \times 0.42 \text{ (allow e.c.f. from (a)(i))} = 0.39\] N A1 [2]

(ii) force reduces to zero in first 0.3 s B1
then increases again in next 0.3 s M1
in the opposite direction A1 [3]

Q30.
Q31.

3 (a) moment: \( \text{force} \times \text{perpendicular distance} \) of force from pivot / axis / point \( \) A1

couple: \( \text{(magnitude of one force} \times \text{perpendicular distance between the two forces} \) \( \) A1 [4]

(b) \( W \times 4.8 = (12 \times 84) + (2.5 \times 72) \) \( \) C1
\( W = 250 \text{ N} \) (248 N) \( \) A1 [2]

(ii) \( \text{either friction at the pivot or small movement of weights} \) \( \) B1 [1]

Q32.

3 (a) \( \text{(i) sum / total momentum (of system of bodies) is constant} \) \( \) M1
or \( \text{total momentum before = total momentum after} \) \( \) \( \) M1
for an isolated system / no (external) force acts on system \( \) A1 [2]

(ii) zero momentum before / after decay \( \) \( \) M1
so \( \alpha \)-particle and nucleus D must have momenta in opposite directions \( \) A1 [2]

(b) \( \text{(i) kinetic energy} = \frac{1}{2} \text{mv}^2 \) \( \) C1
\( 1.0 \times 10^{-12} = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 \) \( \) M1
\( v = 1.7 \times 10^7 \text{ m s}^{-1} \) \( \) A0 [2]

(ii) \( 1.7 \times 10^7 \times 4u = 216u \times V \) \( \) C1
\( V = 3.1 \times 10^9 \text{ m s}^{-1} \) \( \) A1 [2]
\( \text{(accept } 3.2 \times 10^9 \text{ m s}^{-1} \text{, do not accept 220 rather than 216)} \)
Q33.

3 (a) force = rate of change of momentum (allow symbols if defined) B1 [1]

(b) (i) \( \Delta p = 140 \times 10^{-3} \times (5.5 + 4.0) \)
\( = 1.33 \text{ kg m s}^{-1} \) C1
\( A1 \) [2]

(ii) force = 1.33 / 0.04
\( = 33.3 \text{ N} \) M1
\( A0 \) [1]

(c) (i) taking moments about B
\( (33 \times 75) + (0.45 \times g \times 25) = F_a \times 20 \)
\( F_a = 129 \text{ N} \) C1
\( C1 \)
\( A1 \) [3]

(ii) \( F_B = 33 + 129 + 0.45g \)
\( = 166 \text{ N} \) C1
\( A1 \) [2]

Q34.

3 (a) point at which (whole) weight (of body) appears / seems to act ... (for mass need 'appears to be concentrated') M1
\( \text{appears / seems to act ... (for mass need 'appears to be concentrated') A1} \) [2]

(b) (i) point C shown at centre of rectangle ± 5 mm B1 [1]

(ii) arrow vertically downwards, from C with arrow starting from the same margin of error as in (b)(i) B1 [1]

(c) (i) reaction / upwards / supporting / normal reaction force
friction
force(s) at the rod M1
M1
A1 [3]

(ii) comes to rest with (line of action of) weight acting through rod
allow C vertically below the rod
so that weight does not have a moment about the pivot / rod B1 [2]

Q35.
2. (a) torque is the product of one of the forces and the distance between forces the perpendicular distance between the forces 

M1 A1 [2]

(b) (i) torque = 8 \times 1.5 = 12 \text{Nm} 

A1 [1]

(ii) there is a resultant torque / sum of the moments is not zero (the rod rotates) and is not in equilibrium 

M1 A1 [2]

(c) (i) \[ B \times 1.2 = 2.4 \times 0.45 \]

\[ B = 0.9(0) \text{N} \]

C1 A1 [2]

(ii) \[ A = 2.4 - 0.9 = 1.5 \text{N} \text{ / moments calculation} \]

A1 [1]

Q36.

2. (a) (i) force is rate of change of momentum 

B1 [1]

(ii) work done is the product of the force and the distance moved in the direction of the force 

B1 [1]

(b) (i) \[ W = Fs \text{ or } W = m\text{as} \text{ or } W = m(v^2 - u^2)/2 \text{ or } W = \text{force} \times \text{distance} \ s \]

A1 [1]

(ii) \[ as = (v^2 - u^2)/2 \text{ any subject} \]

RHS represents terms of energy \[ W = mas \text{ hence } W = m(v^2 - u^2)/2 \]

KE = \frac{1}{2}mv^2 

A1 [3]

(c) (i) work done = \frac{1}{2} \times 1500 \times [(30)^2 - (15)^2] = 506250 

C1 distance = WD / F = 506250 / 3800 = 133 \text{m} 

or \[ F = ma \quad a = 5.333 \text{ (m/s}^2) \]

\[ v^2 = u^2 + 2as \quad s = 133 \text{m} \]

C1 A1 [2]

(ii) the change in kinetic energy is greater or the work done by the force has to be greater, hence distance is greater (for same force) 

A1 [1]

allow: same acceleration, same time, so greater average speed and greater distance 

Q37.
Q38.

1. (a) scalar has magnitude/size, vector has magnitude/size and direction  
   B1 [1]
(b) acceleration, momentum, weight  
   \(-1\) for each addition or omission but stop at zero  
   B2 [2]

(c) (i) horizontally: \(7.5\cos 40^\circ / 7.5\sin 50^\circ = 5.7(45) / 5.75\) not 5.8 N  
   A1 [1]
(ii) vertically: \(7.5\sin 40^\circ / 7.5\cos 50^\circ = 4.8(2)N\)  
   A1 [1]

(d) either correct shaped triangle  
   correct labelling of two forces, three arrows and two angles  
   M1  
   or correct resolving:  
   \(T_1\cos 40^\circ = T_1\cos 50^\circ\)  
   \(T_1\sin 50^\circ + T_2\sin 40^\circ = 7.5\)  
   A1
   \(T_1 = 5.7(45)\) (N) \(T_2 = 4.8\) (N)  
   \((allow \pm 0.2\ N\ for\ scale\ diagram)\)

Q39.

1. (a) (i) acceleration = change in velocity / time (taken)  
   or acceleration = rate of change of velocity  
   B1 [1]
(ii) a body continues at constant velocity unless acted on by a resultant force  
   B1 [1]

(b) (i) distance is represented by the area under graph  
   distance = \(\frac{1}{2} \times 29.5 \times 3 = 44.3\ m\) (accept 43.5 m for 29 to 45 m for 30)  
   C1  
   A1 [2]
(ii) resultant force = weight – frictional force  
   frictional force increases with speed  
   at start frictional force = 0 / at \(v\), weight = frictional force  
   B1  
   B1 [3]
(iii) 1. frictional force increases  
      2. frictional force (constant) and then decreases  
      B1 [1]
(iv) 1. acceleration = \((v_2 - v_1) / t = (20 - 50) / (17 - 15)\)  
      \(= (-15)\ m/s^2\)  
      C1  
      A1 [2]
2. \(W = F \times me\)  
   \(W = 95 \times 9.81\) (= 932)  
   \(F = (95 \times 15) + 932 = 2400\) (2360) (2357) N  
   C1  
   C1  
   A1 [3]
2 (a) (resultant) force = rate of change of momentum / allow proportional to 
or change in momentum / time (taken) B1 [1]

(b) (i) \( \Delta p = (-) 65 \times 10^{-3} \times (5.2 + 3.7) \) C1
\[ = (-) 0.58 \text{N s} \] A1 [2]

(ii) \( F = \frac{0.58}{7.5} \times 10^{-3} \) A1 [1]
\[ = 7.7(3) \text{N} \]

(c) (i) 1. force on the wall from the ball is equal to the force on ball from the wall but in the opposite direction M1
statement of Newton’s third law can score one mark A1 [2]

2. momentum change of ball is equal and opposite to momentum change of the ball / change of momentum of ball and wall is zero B1 [1]

(ii) kinetic energy (of ball and wall) is reduced / not conserved so inelastic B1 [1]
(Allow relative speed of approach does not equal relative speed of separation.)

Q40.

2 (a) (i) accelerations (A to B and B to C) are same magnitude B1
accelerations (A to B and B to C) are opposite directions B1
or both accelerations are toward B (A to B and B to C) the component of the weight down the slope provides the acceleration B1 [3]

(ii) acceleration = \( g \sin 15^\circ \) C1
\[ s = 0 + \frac{1}{2} at^2 \quad s = 0.26 \text{ / sin } 15^\circ = 1.0 \] C1
\[ t^2 = \frac{1.0 \times 2}{9.8 \times \sin 15^\circ} \quad t = 0.89 \text{ s} \] A1 [3]

(iii) \( v = 0 + g \sin 15^\circ t \) or \( v^2 = 0 + 2g \sin 15^\circ \times 1.0 \) C1
\[ v = 2.26 \text{ m/s} \] A1 [2]
(Using loss of GPE = gain KE can score full marks)

(b) loss of GPE at A = gain in GPE at C or loss of KE at B = gain in GPE at C B1
\[ h_1 = h_2 = 0.26 \text{ m or } \frac{1}{2} mv^2 = mgh \] h2 = 0.5 \times (2.26)^2 / 9.81 = 0.26 m A1 [2]
\[ x = 0.26 / \sin 30^\circ = 0.52 \text{ m} \]
4  (a) torque of a couple = one of the forces / a force x distance  
multiplied by the perpendicular distance between the forces  

(b)  (i) weight at P (vertically) down  
normal reaction OR contact force at (point of contact with the pin) P  
(vertically) up  

(ii) torque = 35 x 0.25 (or 25) x 2  
= 18 (17.5) Nm  

(iii) the two 35N forces are equal and opposite and the weight and the upward /  
contact / reaction force are equal and opposite  

(iv) not in equilibrium as the (resultant) torque is not zero